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OPERATIONS
RESEARCH
CENTER

GUIDE TO SIMULATION SCHEDULING

by

Robert C. Leachman[*]
Sooyoung Kim[*]
Shrane Koung Chou[*]

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[*]Operations Research Center, University of California, Berkeley, California.

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ABSTRACT

Simulation Scheduling is a comprehensive software package for project scheduling and analysis developed at the Operations Research Center of the University of California at Berkeley. It is designed for use in project-oriented production systems which have inflexible resource capacities limiting the execution of multiple projects with uncertain work requirements. The package operates on an IBM mainframe utilizing the VM/SP operating system to compile CMS Fortran interactive commands and batch processing code. As described in this manual, the user may interactively edit data, perform simulations and statistical analysis, create schedules and obtain tabular or graphical output.
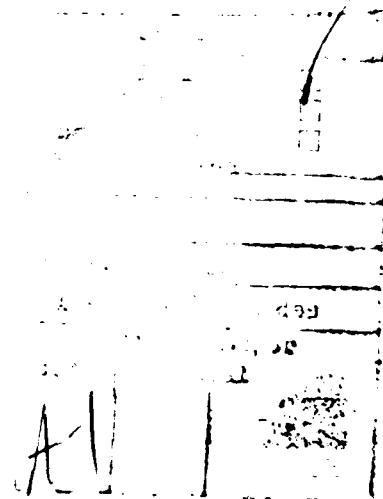
Table of Contents

1. Introduction

Simulation Scheduling is a comprehensive software package for project scheduling and analysis developed at the Operations Research Center of the University of California at Berkeley. It is designed for use in project-oriented production systems which have inflexible resource capacities limiting the execution of multiple projects with uncertain work requirements. Both tabular and graphical output for project schedules and risk analysis are provided.

The software is a result of 10 years of research at U.C.Berkeley concerning the development of mathematical models and techniques for production management, sponsored by the Office of Naval Research and the Puget Sound Naval Shipyard. A biblography of research reports and articles describing the various aspects of this research is provided in section 6.

The simulation scheduling package operates on an IBM mainframe utilizing the VM/SP operating system to compile CMS Fortran interactive commands and batch processing code. With appropriate modification, the Fortran code could be adapted to run on other systems.

Section 2 of this report discusses management use of Simulation Scheduling. In section 3, data requirements are summarized. In section 4, important aspects of the mathematical models of production incorporated into Simulation Scheduling are described.

The on-line User's Manual for Simulation Scheduling is presented in section 5. In this User's Manual, some familiarity with basic CMS commands and Fortran formats is assumed. For a discussion of basic CMS commands, the reader is referred to the manual "Getting Started with CMS", Computing Services, 218 Evans Hall, University of California, Berkeley, CA 94720.

Sample output reports, graphics, and listings of all programs and execution files are provided in the Appendices.

2. *Management Use*

Simulation Scheduling is intended to be used to manage individual projects in conjunction with aggregate planning techniques for inter-project analysis. It is a powerful tool for scheduling project activities and for allocating scarce resources among project activities, and for risk analysis of project budgets and due dates. However, in the management of a project-oriented production system, major decisions must be made involving aggregate-level planning issues which are not considered in the Simulation Scheduling Package. These decisions include the planned allocations of available resource time among projects, and the establishment of major milestone target dates for each project.(For an advanced analytical methodology for aggregate planning, the reader is referred to Leachman and Boysen [1985], Boysen [1983] and Leachman and Boysen [1982].)

Simulation Scheduling requires as input data the allocations of resources to a project and its target milestone dates. Resource allocations to a project are treated by Simulation Scheduling as inviolable capacities for the project, on the grounds that exceeding such allocations would impact other projects. The scheduling algorithms within the Simulation Scheduling package derive schedules meeting the target milestone dates (if feasible) without exceeding the allocated resource levels.

The Simulation Scheduling package may be used to perform two different types of analyses which are termed *deterministic* and *probabilistic*. In deterministic analysis, a project schedule is derived assuming work requirements for the activities of the project are known. In addition to the schedule, resource load profiles corresponding to the schedule are provided as output. In probabilistic analysis, scheduling of the project is simulated many times with activity work requirements randomized according to probability distributions. The

user must specify distributions defining probabilities of unplanned rework activities. In addition, the software incorporates uniform distributions which randomize the work content of planned activities over a 80-120% range of given estimates.

Simulation Scheduling provides confidence curves for the realization date of each milestone and confidence curves for the total hours required of each resource. Resource load profiles reflecting a user-specified confidence level also may be obtained. Reviewing the results of such simulations, the user can assess the risks that trial project milestones and resource budgets can not be met.

3. *Summary of Data Requirements*

The data requirements of Simulation Scheduling are briefly summarized below. A thorough discussion of input procedures and formats is provided in the on-line users manual reproduced in section 5. Some of the data items are novel compared to other project scheduling software; for this reason, a brief discussion is provided in section 4 of the mathematical models of production incorporated in Simulation Scheduling.

CPM Activity Network -- An activity-on-arc network of all planned activities is specified using (I,J) notation. The "normal" duration for each activity is specified.

Resource Hours -- For each activity, estimated total hours of each scarce resource to be applied to the activity are specified. Resources are identified by a designated "shop" number. Subcategories of each resource (for reporting purposes only) are designated by a "work center" number. Activities whose resource utilization levels are not adjustable are so designated with a flag in the "activity type" field.

Target Project Completion Date -- A target due date for completion of all activities is specified.

Target Milestone Dates -- Target due dates for any other events also may be specified. If feasible, schedules will be developed meeting the target dates. Activities following such an event will not be scheduled to start earlier than the target date, unless all predecessors are complete and it is necessary to do so in order to meet other due dates.

Shop Capacities -- Time varying levels are specified for each resource allocated to the project. The user specifies the hours/day of each shop available to the project and an effectivity date such levels apply. Multiple levels and effectivity dates are allowed.

Flow Transfers -- Dependent activities which overlap instead of being separated by strict precedence have a flow transfer percentage specified to define the required lag in the progress of the two activities.

Rework Subnetworks -- For probabilistic analysis, subnetworks describing potential rework are defined. Each rework subnetwork consists of alternative paths of rework activities which may be required following a particular activity in the CPM network.

Calendar Data -- The starting date of the project to be scheduled/simulated and a list of non-working days is provided.

Reporting Dates -- A list of dates for reporting shop and work center loading statistics is provided.

Miscellaneous Parameters -- To initiate Simulation Scheduling, various parameters must be specified. These include the number of simulations to be performed, the number of work days simulated, upper and lower bounds for activity intensity, and the intensity assignment policy.

4. *Mathematical Models of Production*

Simulation Scheduling utilizes the network logic of Critical Path Methods
(CPM). However, restrictive assumptions of CPM have been relaxed so that the
scheduling model more realistically simulates work in a project-oriented pro-
duction system such as a naval shipyard. For example, when using CPM, one
schedules a project assuming the activities have pre-specified durations, or, in
probabilistic analyses, assuming activity durations have pre-specified probabil-
ity distributions. In reality, the durations for many activities are adjustable
according to the intensity of resource applications to the activity. In Simula-
tion Scheduling, the duration for each activity evolves according to the simu-
lated application of resources to the activity. Simulation Scheduling deter-
mines efficient activity durations and schedules by efficiently allocating project
resources among the activities of the project.

The mathematical details of the model of production and of the scheduling
algorithms which are incorporated into Simulation Scheduling are presented in
Dincerler [1985] and in Leachman and Dincerler [1986]. We briefly review the
concepts of the model of production here so that the reader may better
comprehend the use of data in Simulation Scheduling. The review is broken
into sections discussing Resource Utilization, Activity Dependencies, and Proba-
' :listic Networks.

4.1. *Resource Utilization*

In Simulation Scheduling, it is assumed that all scarce resources utilized by
an activity are applied proportionally. Under this assumption, the fraction of
the total requirement of a resource that is applied to an activity on a particular
day is the same for all resources utilized by the activity. This common fraction
is termed the *intensity* of the activity on the particular day. For example, an
intensity of 0.05 on day t would mean 5% of the activity is performed on day t,

i.e., 5% of each of the resource requirements of the activity are consumed on day t.

In CPM techniques, it is assumed that activity intensity is constant from start until completion. The value of this constant is the reciprocal of the pre-specified activity duration. However, in Simulation Scheduling, activity intensity is allowed to vary between upper and lower limits defined by the user. The user defines a normal duration for each activity which corresponds to a normal intensity, i.e., to normal rates of application of resources to the activity. The user also defines upper and lower bounds on activity intensity, expressed as percentages of normal intensity. For example, an intensity upper bound of 150% would mean the rates of resource applications could be up to 150% (3/2) of the rates corresponding to normal duration. If the intensity of the activity were maintained at upper bound from start to finish of the activity, the resulting duration would be only 67% (2/3) of the normal duration. In Simulation Scheduling, the user may identify fixed intensity activities. Fixed intensity activities are ones whose intensity must be held constant at the level corresponding to normal duration. Such activities would include, for example, test activities whose manning levels are not adjustable. All other activities are assumed to have intensities which are adjustable between the upper and lower percentage limits.

Figure 1 displays example intensity patterns. The graphs of activity loading of each resource utilized by the activity would be proportional to the activity's intensity pattern. Graph (a) displays the case in which activity intensity is constant at a level corresponding to normal duration. This is the only case allowed by most CPM techniques. A fixed intensity activity would have such a graph. Graph (b) displays a case in which activity intensity starts at a low level, but is upgraded enough as time goes on so that the activity is still

(a) CONSTANT, NORMAL INTENSITY

Intensity

Upper Bound—

Normal—

Lower Bound—

Start — Finish — Time
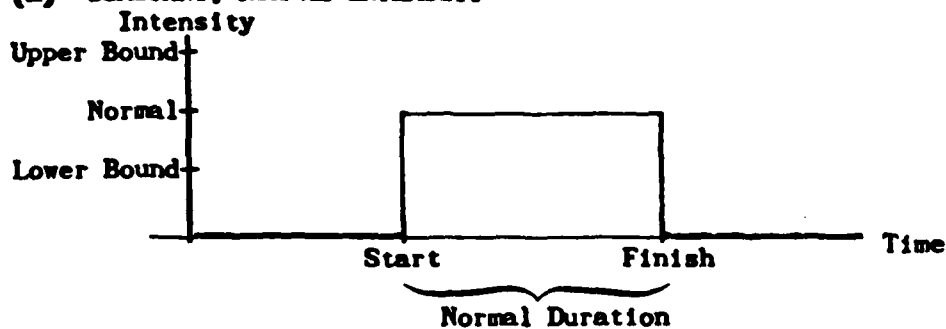
Normal Duration

(b) INTENSITY AT LOWER BOUND AT FIRST, UPGRADED LATER

Intensity

Upper Bound—

Normal—

Lower Bound—

Start — Finish — Time
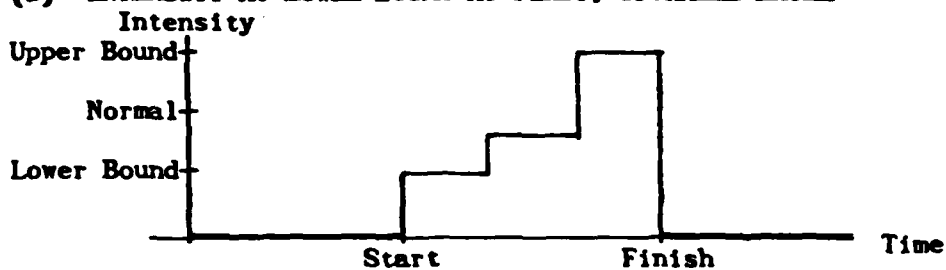
(c) INTENSITY CONSTANT AT UPPER BOUND

Intensity

Upper Bound—

Normal—

Lower Bound—

Start — Finish — Time
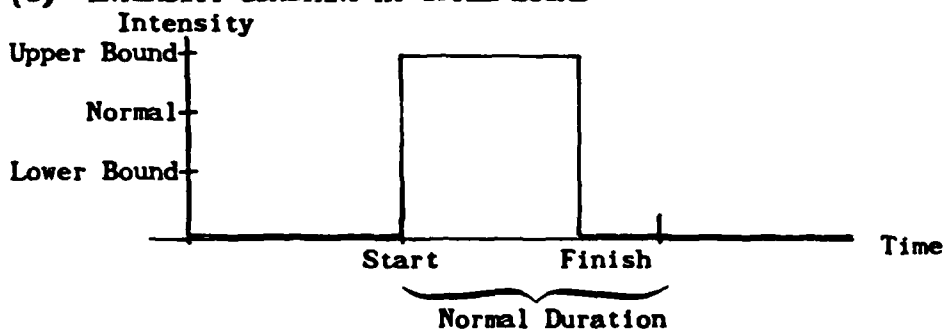
Normal Duration

(d) INTENSITY UPGRADED AND DOWNGRADED

Intensity

Upper Bound—

Normal—

Lower Bound—

Start — Finish — Time
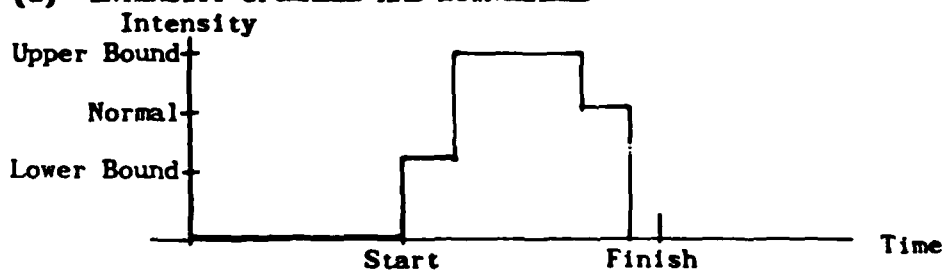
FIGURE 1
EXAMPLE INTENSITY PATTERNS

completed in the normal duration. Such a case might arise in a situation where a number of activities are completed while the activity in question is in progress, and the freed up resources are redirected to the activity in question. Graph (c) displays a case in which activity intensity is constant at the upper bound, as might arise when resources are plentiful. Graph (d) displays the most general case, in which activity intensity is both upgraded and downgraded.

In Simulation Scheduling, the user must select one of two alternative intensity assignment policies, known as Upgrading Only and Upgrading and Downgrading. In the Upgrading Only policy, resources can not be withdrawn from an activity in progress. Graph (a), (b) and (C) represent cases allowed by the Upgrading Only policy; graph (d) represents a case not allowed by the Upgrading Only policy. On the other hand, all cases are admitted under the Upgrading and Downgrading policy. In general, more efficient resource utilization and shorter project durations are feasible when activities can be downgraded as well as upgraded.

4.2. *Activity Dependencies*

In CPM, work flow is represented with strict precedence relationships between activities. In Simulation Scheduling, a more general workflow relationship may be specified, known as a *flow transfer*, which may possibly reduce network size. As an example, suppose 5 pumps are to be fabricated and then installed. As fabrication of each pump is completed, the pump may be installed. Using CPM, it would be inaccurate to have one activity representing the fabrication 5 pumps preceding one activity representing the installation of 5 pumps. To be completely accurate, there would need to be 5 separate pump fabrication activities and 5 separate pump installation activities.

Using Simulation Scheduling, one can define one activity representing the fabrication of 5 pumps and one activity representing the installation of 5

pumps, with a *20%-flow transfer* specified between them. The 20%-flow transfer insures that the fabrication activity is always 20% ahead of the installation activity. For example, installation can not start until fabrication is at least 20% done, installation can not be 50% done unless fabrication is at least 70% done, etc. In this way, the application of resources to install each pump will not be simulated until after the application of resources to fabricate the pump has been simulated, even though only two activities are used.

We remark that a 100%-flow transfer corresponds to familiar strict precedence. In Simulation Scheduling, the default activity network relationship is strict precedence.

4.3. *Probabilistic Networks*

In CPM, a given network of activities is scheduled. In probabilistic analysis using Simulation Scheduling, an overall network is scheduled which consists of the given network appended with randomly generated *rework subnetworks*. Many different overall networks are scheduled in the course of probabilistic analysis. The user of Simulation Scheduling must provide input data defining the probabilities and structure of the rework subnetworks, briefly described as follows.

For each rework subnetwork, the user identifies the activity of the given network which immediately precedes the potential rework. For purposes of discussion, we term this activity in the given network as a "test activity". The rework subnetwork following the test activity is defined in terms of alternative paths of rework activities. Each path is termed a "branch". The user defines the probability that each branch will arise following the test activity. The branch probabilities may sum to less than 1.0 to represent the case in which there is a chance that no rework is required.

A graph of an example rework subnetwork is presented in Figure 2. Activities are represented as arcs identified with (I,J) numbers. Activity (702,336) is the test activity in given network. There are three rework branches following this test activity with probabilities 0.35, 0.20 and 0.05, respectively. The first branch consists of the sequence of activities (R110,R111), (R111,R112), (R112,336). The second branch consists of the sequence of activities (R113,R114), (R114,R115), (R115,336). The third branch consists of a single activity (R116,336).

For each rework activity on each branch, the user specifies a normal resource mix (e.g., normal crew requirement). The user also specifies a probability distribution for the duration of the rework activity that would be realized if the normal resource mix were applied. This distribution is expressed in discrete form. For example, the duration distribution for rework activity (R110,R111) might be 1 day with probability 0.25 and 2 days with probability 0.75. Up to 5 alternative durations for each rework activity may be specified.

TEST ACTIVITY IN
THE GIVEN
NETWORK:

REWORK
SUBNETWORK:
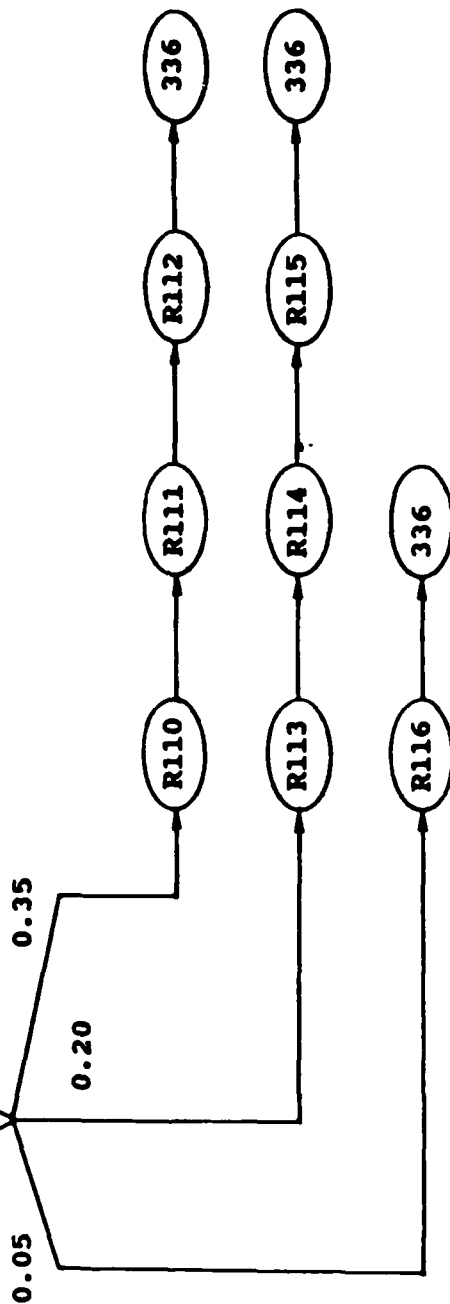
FIGURE 2

EXAMPLE OF REWORK SUBNETWORK

5. *On-Line User's Reference Manual*

The User's Reference Manual is contained in the file "USERS MANUAL" included in the software package. This file may be viewed on-line. Hard-copy may be obtained by printing out the file. A listing of the file follows.

```
************************************************
*                                              *
*    ON-LINE USER'S REFERENCE MANUAL    *
*                                              *
*              FOR                      *
*                                              *
*    SIMULATION SCHEDULING              *
*                                              *
************************************************
```

ROBERT C. LEACHMAN

SOOYOUNG KIM

SHRANE KOUNG CHOL

OPERATIONS RESEARCH CENTER

UNIVERSITY OF CALIFORNIA

BERKELEY, CA 94720

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INTRODUCTION

SIMULATION SCHEDULING IS A COMPREHENSIVE SOFTWARE PACKAGE FOR PROJECT SCHEDULING AND ANALYSIS.   THE PACKAGE REQUIRES BOTH USER-PREPARED INPUT FILES AND INTERACTIVE INPUT TO GENERATE PROJECT SCHEDULES.   BOTH TABULAR AND GRAPHIC OUTPUT ARE OBTAINABLE.

THE PACKAGE CONSISTS OF A SERIES OF CMS FORTRAN EXECS (TERMED "COMMANDS" IN THIS MANUAL) FOR DATA ENTRY, DATA PREPARATION, SCHEDULING SIMULATION, GENERATION OF OUTPUT REPORTS/GRAPHS, AND STORAGE/RETRIEVAL DATA AND RESULTS.   THIS MANUAL DISCUSSES THE USE OF THESE COMMANDS AND THE FORMATS OF INPUT FILES WHICH MUST BE PREPARED BY THE USER.   IN ADDITION, AN ABBREVIATED GUIDE FOR REMOTE LOG-ON TO THE U. C. BERKELEY COMPUTER NETWORK IS PROVIDED.

FOR A GENERAL DISCUSSION OF THE USE, CAPABILITIES AND MODELING ASSUMPTIONS OF SIMULATION SCHEDULING, THE USER IS REFERRED TO "GUIDE TO SIMULATION SCHEDULING", BY R. C. LEACHMAN ET AL., REPORT 86-1, OPERATIONS RESEARCH CENTER, UNIVERSITY OF CALIFORNIA, BERKELEY.

```
III                    **********************************
  I                    *                                *
  I                    *        LOGON PROCEDURE         *
  I                    *                                *
III  *                 **********************************
```

        USING A TERMINAL EQUIPPED WITH A MODEM, THE U.C.BERKELEY
COMPUTER NETWORK MAY BE ACCESSED BY DIALING (415)642-6049 OR
(415)642-6870.   THESE PHONE NUMBERS CONNECT WITH 1200 BAUD
EVEN PARITY PHONE PORTS.   IF YOU PLAN TO UPLOAD/DOWNLOAD
FILES FROM A PERSONAL COMPUTER, PLEASE REFER TO THE "KERMIT"
TERMINAL EMULATOR REFERENCE MANUAL, AVAILABLE FROM U.C.BERKELEY
COMPUTING SERVICES.

        AFTER CONNECTING TO THE U.C.BERKELEY COMPUTER NETWORK,
THE SCREEN WILL DISPLAY LINES AS FOLLOWS.   THE USER SHOULD
KEY IN THE UNDERLINED PORTIONS.

C F C : PORT SELECTOR 2

REQUEST : CAD

ENTER TERMINAL TYPE : VT100 (KEY IN THE APPROPRIATE ID FOR YOUR
                      -----   TERMINAL; IF YOU USE AN IBM PC,
                              THE ID IS "KERMIT")

(USE CONTROL Z TO CLEAN THE SCREEN; THEN TYPE:)

L YOURNAME (L STANDS FOR LOGON, "YOURNAME" MEANS YOUR ACCOUNT
---------- NAME)

ENTER PASSWORD : YOURPW ("YOURPW" MEANS YOUR PASSWORD)

```
III  III     **************************************************
 I    I      *    SUMMARY OF STEPS FOR DATA  PREPARATION,    *
 I    I      *    SIMULATION SCHEDULING , OUTPUT REPORTS,     *
 I    I      *    AND STORAGE/RETRIEVAL OF DATA & RESULTS     *
III  III *   **************************************************
```

A LISTING OF THE STEPS REQUIRED TO OPERATE THE SYSTEM IS PROVIDED
IN THIS SECTION.   A DETAILED DESCRIPTION OF EACH STEP IS PROVIDED
IN FOLLOWING SECTIONS.

A. SUMMARY OF STEPS FOR DETERMINISTIC DATA PREPARATION

   1. PREPARE INPUT FILE NAMED "SHIP DATA"

   2. EXECUTE COMMAND "STARTDAY" (INTERACTIVE INPUT OF PROJECT START
                                 DATE)

   3. EXECUTE COMMAND "CALENDAR" (INTERACTIVE INPUT OF CALENDAR DATA)

   4. EXECUTE COMMAND "MILES"   (INTERACTIVE INPUT OF MILESTONE DATES)

 * 5. EXECUTE COMMAND "GEN"   (COMPILATION OF NETWORK AND CALENDAR
                                 DATA)

 * 6. EXECUTE COMMAND "FTRAN"   (INTERACTIVE INPUT OF FLOW TRANSFERS
                                 AND COMPILATION OF NETWORK DATA)

   7. EXECUTE COMMAND "CAPDATE" (INTERACTIVE INPUT OF CAPACITY
                                 EFFECTIVITY DATES)

   8. EXECUTE COMMAND "SHOPCAP" (INTERACTIVE INPUT OF SHOP CAPACITIES
                                 AND COMPILATION OF CAPACITY DATA)

   9. EXECUTE COMMAND "REPDATE" (INTERACTIVE INPUT OF REPORTING DATES)

 B. SUMMARY OF STEPS FOR PROBABILISTIC DATA PREPARATION

   1. PREPARE INPUT FILE NAMED "REWORK DATA"

   2. PREPARE INPUT FILE NAMED "RRES DATA"

 * 3. EXECUTE COMMAND "SIMGEN"   (COMPILATION OF PROBABILISTIC DATA)

 * NOTE: THESE STEPS MUST BE PERFORMED EVEN WHEN DATA IS RETRIEVED.
         SEE PART E. BELOW.

------ 2 ------

C. SUMMARY OF STEPS FOR OPERATION OF SIMULATION SCHEDULING

   1. PREPARE INPUT FILE NAMED "BPARAMR DATA" (OPTIONAL)

   2. EXECUTE COMMAND "SIMSCHED" (INTERACTIVE INPUT OF OPTIONS AND
      PARAMETERS AND EXECUTION OF SCHEDULING)

D. SUMMARY OF STEPS FOR OUTPUT REPORTS AND GRAPHICS

   1. TO GET REPORTS, EXECUTE COMMAND "CUTREP" (INTERACTIVE INPUT
      OF OPTIONS).

   2. TO GET GRAPHS, EXECUTE COMMAND "GRAPH" (INTERACTIVE INPUT OF
      OPTIONS).

E. SUMMARY OF STEPS FOR SAVING AND RETRIEVING DATA/RESULTS

   1. TO SAVE, EXECUTE COMMAND "KEEP" (INTERACTIVE INPUT OF PROJECT
      NAME).

   2. TO RETRIEVE, EXECUTE COMMAND "RETRIEVE" (INTERACTIVE INPUT OF
      PROJECT NAME).   AFTER RETRIEVING DATA, STEPS 5 & 6 OF PART
      A AND STEP 3 OF PART B MUST BE PERFORMED. OTHER STEPS OF DATA
      PREPARATION NEED TO BE PERFORMED ONLY IF DATA IS TO BE CHANGED.

```
III III III      ¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢
 I   I   I       ¢          OPERATING INSTRUCTIONS         ¢
 I   I   I       ¢                 FOR                     ¢
 I   I   I       ¢        DETERMINISTIC DATA PREPARATION    ¢
III III III ¢    ¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢
```

1. PREPARE ORIGINAL NETWORK FILE

I. PREPARE THE ORIGINAL NETWORK DATA FILE NAMED "SHIP DATA". THE
   FORMAT AND DESCRIPTION OF THIS FILE ARE AS FOLLOWS:

DATA ITEM	TYPE	FIELD
I NODE	I4	16-19
J NODE	I4	22-25
SHOP NUMBER	I3	27-29
WORK CENTER	I2	30-31
HOURS	I5	34-38
NORMAL DURATION	I3	41-43
ACTIVITY TYPE	I1	62

NOTE:
IN ACTIVITY TYPE, IF THE INTENSITY OF THE ACTIVITY IS FIXED
PLEASE INPUT 1, IF THE INTENSITY OF THE ACTIVITY IS VARIABLE
LEAVE IT BLANK.

EXAMPLE:

	ACT. NO. I	NO. J	SH/WC	MAN HOUR	NORMAL DUR.			ACT. TYPE
3902599311843	0303	0342	0262	720	100	102683	041985	1
3902599311867	0315	0342	0262	720	015	070284	041985	
1002599711365	0303	0306	0280	134	003	102683	102883	1
3902599311843	0303	0318	0230	8784	180	102683	072084	
1002585311400	0303	0342	0280	56	100	102683	041985	
1602599321643	0303	0342	0280	792	100	102683	041985	
1602599221820	0309	0853	0280	40	100	103183	011885	

II. IF THE ORIGINAL NETWORK FILE IS STORED ON A TAPE, USE THE
    FOLLOWING PROCEDURE TO READ IT:

A. LABEL THE TAPE NAME WITH THE NAME "SHIP" AND DELIVER TO
   U.C. COMPUTER CENTER.

B. USE COMMAND "DIRM MOPK" TO FIND THE DISK WRITE PASSWORD OF
   YOUR ACCOUNT.   HERE, WE ASSUME IT IS "SHIPYARD".

C. USE COMMAND "TAPDSK" TO READ THE DATA FROM TAPE, THEN
   TYPE IN THE FOLLOWING COMMAND TO SUBMIT JOB.

       "SUBMIT TAPDSK CLASS B"

   THE TAPE WILL BE LOADED AT THE U.C. COMPUTER CENTER AND
   THE CONTENTS READ INTO YOUR ACCOUNT.

2. ENTER PROJECT STARTING DATE
==============================

     USE COMMAND "STARTDAY" TO RUN THE PROGRAM.   THE PROGRAM WILL
ASK YOU TO INPUT THE PROJECT (OR REMAINING PROJECT) STARTING DATE.
EVENTS WHICH HAVE NO PREDECESSORS AND WHICH ARE NOT MILESTONES
WILL BE ASSIGNED THIS DATE.

   EXAMPLE : (INPUT THE UNDERLINED PORTION)

   STARTDAY

   PLEASE INPUT THE STARTING DATE OF THE PROJECT (MM,DD,YY)

   9,3,83
   ------

3. ENTER CALENDAR DATA
=====================

   USE COMMAND "CALENDAR" TO RUN THE PROGRAM.   THE PROGRAM
   WILL ASK YOU TO INPUT WORKING DAY OPTIONS FOR SATURDAY AND
   SUNDAY.   THE PROGRAM WILL GENERATE A WORKING DAY TABLE FOR
   TEN YEARS USE.   PLEASE FOLLOW THE INSTRUCTIONS DISPLAYED
   ON THE SCREEN.

   EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

   CALENDAR

   IN YOUR FACILITY, IS SATURDAY A WORKING DAY?
   IF YES PLEASE INPUT 1, IF NOT PLEASE INPUT 0.

   0
   -

   IN YOUR FACILITY, IS SUNDAY A WORKING DAY?
   IF YES PLEASE INPUT 1, IF NOT PLEASE INPUT 0.

C

ENTER THE YEAR WHICH YOU WANT AS THE STARTING YEAR.   THE
PROGRAM WILL GENERATE THE WORKING DAY TABLE FOR 10 YEAR'S USE
STARTING FROM THE YEAR YOU HAVE INPUT

19C3

ENTER ANY DATE OF A SUNDAY BETWEEN YEAR 1983 AND YEAR 1992
(MM,DD,YY)

2,9,86

YOU HAVE INPUT DATE: 2 9 1986, IT IS A SUNDAY
BETWEEN YEAR 1983 AND YEAR 1992

INPUT ALL HOLIDAYS (OTHER THAN SUNDAYS & SATURDAYS):MM,DD,YY

AT END OF DATA, PLEASE PRESS RETURN TWICE.
IF THE HOLIDAY DATE IS THE SAME EVERY YEAR,THEN
INPUT : MONTH,DAY,0

1,1,0

1,20,86

7,4,0
 • • •
 • • •

IF YOU WANT TO CHECK THE HOLIDAYS YOU HAVE INPUT, PLEASE
LOOK AT THE FILE "HOLIDAY DATE".

IF YOU WANT TO CHECK THE WORKING DAY TABLE, YOU CAN LOOK
AT THE FILE "WORKING DAY".

4. INPUT TARGET DATES FOR MILESTONES
==

USE "MILES" COMMAND TO RUN FORTRAN PROGRAM.   THE PROGRAM WILL
ASK YOU TO INPUT THE TARGET FINISH DATE FOR EACH MILESTONE.

------ 6 ------

EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

MILES

ENTER NUMBER OF MILESTONES TO BE ADDED

5
-

ENTER EVENT NUMBER OF MILESTONE 1
AND TARGET MILESTONE DATE. (MMDDYY OR 0 IF NONE, E.G. 303,
122585 OR 303,0)

102,0

ENTER EVENT NUMBER OF MILESTONE 2
AND TARGET MILESTONE DATE. (MMDDYY OR 0 IF NONE, E.G. 303,
122585 OR 303,0)

303,122585

     .   .   .
     .   .   .

5. CREATE FILES USED BY THE SYSTEM
==================================

    USE COMMAND "GEN" TO RUN THE PROGRAM. THE PROGRAM WILL GENERATE
    MANY FILES FOR INTERNAL USE.

    NOTE :

    A. THE SYSTEM WILL ONLY ACCEPT RESOURCE CAPACITIES AT THE SHOP
       LEVEL.   IF YOU WANT TO SPECIFY A WORK CENTER CAPACITY, PLEASE
       INPUT "1" IN FRONT OF THE SHOP NUMBER, EG. 13108 INSTEAD OF
       3108 IN THE ORIGINAL NETWORK FILE.   IN CASE OF TWO OR MORE
       CAPACITATED WORK CENTERS IN ONE SHOP YOU CAN ADD "2", "3",....
       IN FRONT OF THE SHOP NUMBER, EG. 23109, 33112....   IT MEANS
       IN SHOP 31 WE WANT TO CONTROL THE RESOURCES USED IN WORK CENTERS
       8,9,12,...

    B. IF THERE ARE ANY CYCLES IN THE NETWORK, THE SCREEN WILL DISPLAY
       A MESSAGE. PLEASE CHECK FILE "BBRANK1 OUT" TO SEE WHERE CYCLES
       EXIST.   CORRECT ORIGINAL DATA FILE, AND REPEAT THIS STEP.

6. INPUT FLOW TRANSFER COEFFICIENTS
=====================================

USE COMMAND "FTRAN" TO RUN THE PROGRAM AND THE PROGRAM WILL ASK
YOU TO INPUT THE FLOW TRANSFER COEFFICIENT. EVEN IF YOU ALREADY
HAVE ENTERED THE FLOW TRANSFERS, YOU MUST EXECUTE THIS PROGRAM
IF ANY CHANGES TO THE NETWORK HAVE BEEN MADE.

EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

FTRAN

IS THE FILE "BBTRC DATA" OF FLOW-TRANSFER INPUTS ALREADY COMPLETE?
IF YES, EXEC WILL COMPILE THE NETWORK
Y IF YES, N IF YOU WANT TO ENTER NEW DATA FOR FLOW-TRANSFERS.

N
-

ENTER NODE AND COEFFICIENT OF FLOW TRANSFER
(E.G. 303,0.5 FOR NODE 303 AND COEFFICIENT 0.5)
END OF DATA; TYPE RETURN ONLY

704, 0.80

1016, 0.90

   "   "
   "   "

NOTE : THIS PROGRAM PREPARES THE FILE OF TRANSFER COEFFICIENTS
       BETWEEN EACH PREDECESSOR AND ITS FOLLOWERS AS WELL AS
       BETWEEN EACH FOLLOWER AND ITS PREDECESSORS.

7. PREPARE CAPACITY FILE
===========================

I. USE COMMAND "CAPDATE" TO RUN FORTRAN PROGRAM AND THE PROGRAM
   WILL ASK YOU TO INPUT CAPACITY EFFECTIVITY DATES
   INTERACTIVELY.

   EXAMPLE :

   CAPDATE

   ENTER DATES WHEN SHOP CAPACITIES CHANGE.   STARTING DATE OF

PROJECT IS 9   3 1983, PLEASE ENTER ALL DATES AFTER THIS
TIME WHEN SHOP CAPACITIES CHANGES.
IF END OF DATA PLEASE PRESS RETURN TWICE.

1,5,86

3,20,86

    • • •

    • • •

II. USE COMMAND "SHOPCAP" TO RUN THE PROGRAM & THE PROGRAM WILL ASK
    YOU IF YOU WISH TO INPUT THE SHOP CAPACITIES CORRESPONDING TO
    EACH EFFECTIVITY DATE.   IF YOU ALREADY HAVE THE FILE
    "BBBCAP DATA" YOU CAN ASK THE PROGRAM TO COMPILE THE DATA
    DIRECTLY.

    EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

    SHOPCAP

    DO YOU ALREADY HAVE THE FILE BBBCAP DATA FOR SHOP CAPACITY
    INPUT ?   IF YES, EXEC WILL COMPILE THE CAPACITY DATA
    Y IF YES, N IF YOU WANT TO ENTER NEW DATA FOR SHOP CAPACITY.

    N
    -

    ENTER SHOP, NUMBER OF EFFECTIVITY DATE, AND CAPACITY EXPRESSED
    IN HOURS/DAY. (E.G. 31,4,100 FOR SHOP 31, 4TH EFFECTIVITY DATE,
    100 MANHOURS/DAY)
    (IF NO CAP BOUND FOR ALL SHOPS, ENTER 0,0,9999)
    FIRST EFFECTIVITY DATE IS STARTING DATE OF PROJECT, SECOND
    EFFECTIVITY DATE IS THE FIRST DATE ENTERED IN "CAPDATE", ETC.
    AT END OF DATA, TYPE RETURN ONLY

    0,0,9999

    END OF DATA, THANK YOU .....

    AFTER ENTERING ALL DATA, EXEC WILL COMPILE THE CAPACITY DATA.

8. DEFINE REPORTING DATES FOR STATISTICS ON RESOURCE USE
===

USE COMMAND "REPDATE" TO RUN THE PROGRAM, FOLLOW THE INSTRUCTIONS
ON THE SCREEN AND INPUT THE REPORTING CALENDAR DATES WHICH WILL
DEFINE PERIODS OF TIME OVER WHICH AVERAGE RESOURCE USAGE WILL
BE REPORTED.   THE PROGRAM WILL AUTOMATICALLY INCLUDE THE CAPACITY
CHANGE DATES IN THE REPORTING DATES, SO, YOU JUST INPUT THE
REPORTING DATES OTHER THAN CAPACITY CHANGE DATES.

EXAMPLE : SAME AS THE EXAMPLE IN SECTION 7.1.

9. RUN DETERMINISTIC NETWORK PROBLEM
=======================================

AT THIS POINT, ALL THE DATA FOR DETERMINISTIC ANALYSIS ARE READY.
IF YOU WANT TO RUN THE DETERMINISTIC ANALYSIS, YOU MAY SKIP
THE NEXT STAGE (PREPARATION OF THE PROBABILITISTIC DATA), AND GO
DIRECTLY TO SECTION V. USE COMMAND "SIMSCHED" FOR SIMULATION
SCHEDULING.   FOR DETAILS PLEASE SEE SECTION V, OPERATING
INSTRUCTIONS FOR SIMULATION SCHEDULING.

```
 ***************************************************************
 *      END OF DETERMINISTIC DATA PREPARATION           *
 ***************************************************************
```

```
111 111    111     ***************************************************
  1   1      1     *            OPERATING INSTRUCTIONS            *
  1    1    1      *                    FOR                      *
  1     1 1        *         PROBABILISTIC DATA PREPARATION      *
111       1  *     ***************************************************
```

THE FOLLOWING PROCEDURES CREATE DATA FOR TEST REWORK LOOPS.

1. CREATE FILE OF REWORK ACTIVITIES
==

DESCRIBE REWORK SUBNETWORKS IN TERMS OF AN INPUT FILE FOR REWORK
ACTIVITIES LABELED BY THE (I,J) PAIR IDENTIFYING THE TEST WHICH
THE POTENTIAL REWORK FOLLOWS.   THIS FILE IS CALLED "REWORK DATA"
IN FORMAT(A4,1X,A4,1X,F4.2,1X,A4,1X,A4,1X,I1,5(1X,I3,1X,F4.2)).
A SMALL EXAMPLE FOLLOWS :

TEST I	ACT. J	BRNC PROB	REWORK I	ACT. J	TYPE	D1	P1	D2	P2	D3	P3	D4	P4	D5	P5
9095	903	.22	R111	903	1	1	.99	2	.01						
9095	903	.22	R112	903		1	.99	2	.01						
8897	903	.22	R113	903	1	1	.99	0	.01						
8939	903	.45	R114	903		1	.99	2	.01						
8939	903	.05	R115	R116		1	1.00								
8939	903		R116	R117		2	1.00								
8939	903		R117	R118		1	1.00								
8939	903		R118	903		1	.40	0	.60						
303	860	.80	R928	860		4	.30	6	.20	7	.30	13	.20		
8066	8349	.43	R126	8349		2	.18	3	.21	4	.26	5	.24	7	.11
8066	8349	.06	R127	8349		2	.12	4	.14	5	.10	5	.03	0	.61
805	810	.50	R128	810		1	.72	2	.26	3	.02				

IN THE FIRST TWO ROWS, POTENTIAL REWORK FOLLOWING THE TEST (9095,
903) IS DESCRIBED. WITH PROBABILITY 0.22, REWORK ACTIVITY (R111,903)
WILL BE REQUIRED AFTER (9095,903) IS EXECUTED, BUT BEFORE ACTIVITIES
WITH I=903 CAN BE INITIATED.   WITH PROBABILITY 0.22, REWORK ACTIVITY
(R112,903) WILL BE REQUIRED INSTEAD.   WITH PROBABILITY 1.00-(0.22
+0.22)=0.56, NO REWORK FOLLOWING THE TEST (9095,903) IS REQUIRED.
BOTH ACTIVITIES (R111,903) AND (R112,903) HAVE A NORMAL DURATION
OF 1 DAY WITH PROBABILITY 0.99 AND A NORMAL DURATION OF 2 DAYS WITH
PROBABILITY 0.01.

THE ACTIVITY (R111,903) IS A FIXED INTENSITY ACTIVITY (TYPE 1),
WHILE (R112,903) IS A VARIABLE INTENSITY ACTIVITY (BLANK TYPE).

NOTE THAT A REWORK BRANCH MAY INCLUDE MORE THAN ONE ACTIVITY
IN ORDER TO MODEL MAJOR REWORK INVOLVING SEQUENTIAL STEPS WITH
DIFFERENT RESOURCE.

MIXES.   FOR EXAMPLE, THE TEST (8939,903) HAS TWO POSSIBLE REWORK
BRANCHES FOLLOWING THE TEST.   NO REWORK IS REQUIRED WITH PROBABILITY
1.00-(0.45+0.05)=0.50.   BRANCH (R114,903) IS REQUIRED WITH PROBA-
BILITY 0.45. BRANCH (R115,R116)-(R116,R117)-(R117,R118)-(R118,903)
IS REQUIRED WITH PROBABILITY 0.05.

2.CREATE FILE OF REWORK RESOURCES REQUIREMENT

CREATE THE FILE "RRES DATA" EXPRESSING SHOP/WORK CENTER AND CREW
REQUIREMENTS FOR REWORK IN THE FORMAT(14X,A5,A5,1X,I5,2X,I1).
A SMALL EXAMPLE FOLLOWS :

TEST ACT.		BRNCH	REWORK ACT.			NO OF
I	J	PROB	I	J	SH/WC	HOURS/DAY
9095	903	.22	R111	903	7204	8
9095	903	.22	R111	903	5602	8
9095	903	.22	R111	903	3802	8
9095	903	.22	R112	903	7204	8
9095	903	.22	R112	903	5602	8
9095	903	.22	R112	903	3805	8
8897	903	.22	R113	903	7204	8

NOTE THAT RESOURCE RATES (EG. 8 MAN-HOURS/DAY) ARE SPECIFIED INSTEAD
OF TOTAL RESOURCE HOURS.   TOTAL RESOURCE HOURS ARE COMPUTED AS THE
RATE PER DAY TIMES THE PROBABILISTIC NORMAL DURATION SPECIFIED IN
"REWORK DATA".

3. CREATE SIMULATION INPUT FILES

   I. DEFINE STORAGE 4 MEGABYTES

   DEFINE STORAGE 4M

   II. USE "SIMGEN" COMMAND TO EXECUTE THE PROGRAM CREATING
   SIMULATION INPUT.

   ```
   ********************************************************
   *     END OF PROBABILISTIC DATA PREPARATION           *
   ********************************************************
   ```

```
III   III     ********************************************************
 I    I       *                                                      *
 I   I        *              OPERATING INSTRUCTIONS                   *
  I  I        *                     FOR                               *
   I I        *            SIMULATION SCHEDULING                      *
    I  *      ********************************************************
```

I. IF YOU PLAN TO RUN THE PROGRAM IN BATCH MODE YOU SHOULD
   PREPARE THE PARAMETERS' FILE "BPARAMR DATA" FORMAT(50X,I5).
   IF YOU RUN THE PROGRAM INTERACTIVELY, THE PROGRAM WILL ASK
   YOU TO INPUT THE PARAMETERS ON THE SCREEN.   AN EXAMPLE OF
   THIS FILE FOLLOWS :

   EXAMPLE : FILE "BPARAMR DATA"

   PROJECT NAME STARTING IN COLUMN 1 (E.G., BAINBRIDGE)
   SIMULATION PRMTRS ASSIGNMENT POLICY   1
                     INTENSITY LOWER BOUND   50
                     INTENSITY UPPER BOUND   100
                     REWORK LOOPS?   1
                     NUM OF WORK DAYS SIMULATED   1500
                     NUMBER OF SIMULATIONS   1
                     TARGET FINISH TIME   121085
                     REPORT STYLE   1

  NOTE: A. IN ASSIGNMENT POLICY INPUT "1" FOR UPGRADING INTENSITY
           ONLY, OR "2" FOR UP & DOWN GRADING.

        B. IF THERE ARE REWORK LOOPS PLEASE INPUT "1", IF NOT
           PLEASE INPUT "0".

        C. THE TARGET FINISH TIME IS THE DESIRED FINISH TIME FOR
           THE PROJECT.   IF YOU ENTER "0" THE PROGRAM WILL USE
           THE EARLY FINISH TIME CALCULATED FROM CPM AS THE TARGET
           FINISH TIME.

        D. IN REPORT STYLE, IF YOU WANT THE REPORTING TIMES
           EXPRESSED IN TERMS OF CALENDAR DATES PLEASE INPUT "1".
           IF YOU WANT TIMES EXPRESSED IN TERMS OF WORKING DAYS
           SINCE START OF PROJECT, PLEASE INPUT "0".

 II. USE COMMAND "SIMSCHED" TO RUN THE PROGRAM.   THE PROGRAM WILL
     ASK YOU TO CHOOSE BATCH OR INTERACTIVE OPERATION.   PLEASE
     REFER TO THE FOLLOWING EXAMPLE.

    EXAMPLE :

    DEFINE STORAGE 4M

                    ------- 13 -------

     I CMS
```

I CMS
-----

SIMSCHED
--------

```
****************************************************
*       S    I    M    S    C    H    E    D       *
****************************************************
```

SELECT ONE OF THE FOLLOWING OPTION CODES :

1 : INTERACTIVE RUN WITHOUT TEST-REWORK LOOPS (DETERMINISTIC RUN)
2 : INTERACTIVE RUN WITH   TEST-REWORK LOOPS (STOCHASTIC   RUN)
3 : BATCH   RUN WITHOUT TEST-REWORK LOOPS (DETERMINISTIC RUN)
4 : BATCH   RUN WITH   TEST-REWORK LOOPS (STOCHASTIC   RUN)

- BATCH RUN WILL BE SUBMITTED AFTER 20:00

1
-

IF YOU RUN BATCH THE PROGRAM WILL ASK YOU :

ENTER THE LIMIT OF CPU SECONDS FOR YOUR BATCH RUN (O IF NONE)

600

(IN A LARGE NETWORK, ALLOW ABOUT 20 SECONDS FOR EACH
 SIMULATION)

ENTER OPTION 0 = READ PARAMETERS FROM INPUT FILE
              1 = INTERACTIVE INPUT

1
-

ENTER PROJECT NAME (MAX. 50 CHARACTERS)

BAINBRIDGE

ENTER ASSIGNMENT POLICY :
1 = UPGRADING ONLY, 2 = UP & DOWNGRADING

1
-

ENTER LOWER & UPPER BOUNDS OF INTENSITY :
(USE PERCENTAGE VALUES EG. 100 FOR 100%)

```
50,150
-----

ARE THERE ANY REWORK LOOPS ? (Y OR N )

N
-

ENTER NUMBER OF SIMULATIONS :
1 = SINGLE RUN WITH DETERMINISTIC RESOURCE REQUIREMENTS
N = N SIMULATIONS WITH RANDOM RESOURCE REQUIREMENTS

20
--

ENTER MAXIMUM NUMBER OF WORKING DAYS TO BE SIMULATED

9999
----

ENTER NUMBER OF REPORTING DATES WHICH YOU WANT

20
--

ENTER PROJECT TARGET FINISH TIME (MMDDYY, 0 IF NONE )

121085
------

CHOOSE ONE OPTION FOR REPORT DATES :
0 = REPORT IN WORKING DATES
1 = REPORT IN CALENDAR DATES


1
-

THANK YOU.    IN PROCESSING......
READING FOLL & PRED
READING ACTIVITY-RESOURCE DATA
READING TRANSFER COEFFICIENTS
READING ACTIVITIES DATA
READING REWORK-ACTIVITIES DATA
READING CAPACITY(TIME, RESOURCE)
READING RANK OF ACTIVITIES
END OF DATA . INITIALIZE VALUES FOR SIMULATION
** START SIMULATION
** RUN CYCLE = 1
REPORTING EVENT. TIME IS     14.00000
REPORTING EVENT. TIME IS     35.00000
REPORTING EVENT. TIME IS     57.00000
          *      *     *    *      *
          *      *     *    *      *
          *      *     *    *      *
```

```
SCHEDULER TABLE IS EMPTY.
END OF SIMULATION.    TIME IS       706.000000


        ********************************************
        *                                          *
        *    END OF SIMULATION SCHEDULING          *
        *       OPERATING INSTRUCTIONS             *
        *                                          *
        ********************************************
```

```
111  111 111     ************************************************
 1    I   1      *                                              *
  1   1   1      *       OUTPUT REPORTS AND GRAPHICS             *
   1 1    1      *                                              *
     1    111 *  ************************************************
```

A. IF YOU WANT TO SEE THE PROJECT SCHEDULE, PLEASE LOOK AT THE FILE
   "SCHEDULE OUT". IN A PROBABILISTIC RUN, ONLY THE SCHEDULE OF THE
   FIRST SIMULATION IS KEPT IN THIS FILE.

B. IN ORDER TO OBTAIN REPORTS OF THE SIMULATION RESULTS, A
   STATISTICAL PROGRAM CALCULATES THE AVERAGE RESOURCES USED AT
   EACH CONFIDENCE LEVEL FOR EACH SHOP OR WORK CENTER IN EACH
   PERIOD DEFINED BY THE REPORTING DATES.   CONFIDENCE LEVELS
   FOR THE DATES EACH MILESTONE IS REALIZED AND FOR THE
   TOTAL AMOUNT EACH RESOURCE IS USED ARE ALSO CALCULATED.

   USE COMMAND "OUTREP" TO RUN FORTRAN PROGRAM.   THE PROGRAM
   WILL ASK FOR INTERACTIVE INPUT AS FOLLOWS.

   EXAMPLE : (INPUT UNDERLINED PORTIONS)

   OUTREP

   SELECT ONE OF THE FOLLOWING OPTION CODES FOR OUTPUT (REPORT OUT):

      0 : PRINT
      1 : WRITE TO DISK IN A FILE NAMED 'REPORT OUT'

   1
   -

   ENTER REPORTING OPTION CODE :

   1 = SHOPS ONLY
   2 = WORKCENTERS ONLY
   3 = SHOPS & WORKCENTERS

   3
   -

   ENTER CALENDAR OPTION CODE :

   0 = REPORT IN WORKING DAYS
   1 = REPORT IN CALENDAR DATES

   1
   -

C. FOR EXAMPLES OF THE OUTPUT, PLEASE REFER TO APPENDIX A OF

"GUIDE TO SIMULATION SCHEDULING".

D. IN ORDER TO OBTAIN GRAPHICAL OUTPUT, YOU SHOULD LOGON TO THE
SYSTEM USING A TERMINAL WITH GRAPHICS CAPABILITY, SUCH AS A
TEKTRONIX 4015.   USE COMMAND "GRAPH" TO RUN FORTRAN PROGRAM.
THE PROGRAM WILL ASK YOU TO SELECT WHICH RESULTS YOU WANT TO
BE GRAPHED.

EXAMPLE : (INPUT UNDERLINED PORTIONS)

GRAPH

```
    ***********************************
    *      G R A P H S      *
    ***********************************
```

SELECT GRAPH TYPE YOU WANT :
1 = MILESTONE
2 = LOAD PROFILE
3 = TOTAL RESOURCE USAGE
4 = TERMINATE EXECUTION

2
-

  *****   L O A D   PROFILE   *****

CHOOSE OPTION : 0 = WORKCENTER LEVEL
                  1 = SHOP   LEVEL

1
-

CHOOSE OPTION : 0 = IN WORKING DAYS
                  1 = IN CALENDAR DATE

1
-

ENTER SHOP NUMBER AND CONFIDENCE LEVEL (IN %)

31,90

NEED MORE? Y IF YES, N IF NO

Y
-

SELECT GRAPH TYPE YOU WANT :
1 = MILESTONE
2 = LOAD PROFILE

```
        3  =   TOTAL RESOURCE USAGE
        4  =   TERMINATE EXECUTION

        1
        -


        *****      MILESTONE GRAPH    *****

    ENTER MILESTONE NODE YOU WANT

    303
    ---

    NEED MORE?  Y IF YES,  N IF NO

    Y
    -



    SELECT GRAPH TYPE YOU WANT :
    1  =   MILESTONE
    2  =   LOAD PROFILE
    3  =   TOTAL RESOURCE USAGE
    4  =   TERMINATE EXECUTION

    3
    -


    *****     TOTAL  RESOURCE USAGE      *****

    ENTER SHOP NUMBER, OR 9999 FOR GRAND TOTAL

    9999
    ----

    NEED MORE ?  Y IF YES,  N IF NO

    N
    -


            **********************************************
            *  END OF OUTPUT  REPORTS AND GRAPHICS  *
            **********************************************
```

```
III   III III III    *********************************************
 1    1   I   I       *                                           *
  1  I    I   I       *    SAVING AND RETRIEVING DATA AND RESULTS  *
  I I     I   I       *                                           *
    I     III III *   *********************************************
```

I. IF YOU WANT TO SAVE THE DATA AND RESULTS FOR A PARTICULAR
    PROJECT PLEASE USE COMMAND "KEEP". THE PROGRAM WILL ASK YOU
    TO INPUT THE PROJECT NAME AS THE FILE NAME. THE PROGRAM WILL
    SAVE THE INPUT DATA & RESULTS, SO YOU CAN USE THE SAME
    PROCEDURE TO RUN OTHER PROJECTS WITHOUT LOSING DATA FOR THE
    PROJECT

    EXAMPLE : (INPUT THE UNDERLINED PORTION)

    KEEP

       *******   KEEP   *******

    THIS EXEC COPIES THE INPUT FILES AND RESULTS AND LABELS THEM
    WITH THE PROJECT I.D. TO KEEP THEM ENTER THE PROJECT I.D.
    (UP TO 8 CHARACTERS)

    BAINBRID

II. IF YOU WANT TO RETRIEVE OLD DATA TO MAKE NEW ANALYSIS,
    PLEASE USE COMMAND "RETRIEVE". THE PROGRAM WILL ASK YOU TO
    INPUT THE PROJECT I.D. AND THE PROGRAM WILL RETRIEVE THE FILES
    AND GIVEN THEM ACTIVE FILENAMES AND FILEMODES.

    EXAMPLE : (INPUT UNDERLINED PORTOIN)

    RETRIEVE

       *******   RETRIEVE   *******

    THIS EXEC RETRIEVES THE FILES TO THEIR ORIGINAL NAMES AND MODES.

    ENTER THE PROJECT I.D. (UP TO 8 CHARACTERS)

    BAINBRID

              ****
              *   END OF SAVING AND RETRIEVING   *
              *   DATA AND RESULTS   *
              ****
```

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Appendix A. Sample Output Reports and Graphics

PROJECT NAME : BAINBRIDGE   20 RUN(S) USING UPGRADING ONLY INTENSITY RANGE   6C -   120

PROJECT START DATE :   9   9   1 1983

ACTIVITY INTERNAL #	I	J	SCHEDULE START DATE	FINISM DATE
1	1	303	9 1 83	10 5 83
2	1	309	9 1 83	12 26 83
3	1	312	1 17 84	1 19 84
4	1	336	9 1 83	12 26 83
5	1	342	2 20 84	3 16 84
6	1	805	9 1 83	1 3 84
7	1	807	9 20 83	2 14 84
8	1	810	9 1 83	1 12 84
9	1	812	9 2 83	1 27 84
10	1	815	9 2 83	2 16 84
11	1	820	9 2 83	2 10 84
12	1	825	9 2 83	7 20 84
13	1	828	9 1 83	9 6 84
14	1	830	9 1 83	9 14 84
15	1	835	9 1 83	8 6 84
16	1	836	11 29 83	11 30 84
17	1	838	9 16 83	10 10 84
18	1	840	9 1 83	10 2 84
19	1	843	9 1 83	11 6 84
20	1	850	9 28 83	11 1 85
21	1	860	9 20 83	1 3 85
22	1	863	9 2 83	12 25 84
23	1	903	9 1 83	1 30 84
24	1	2306	9 1 83	9 12 83
25	1	2513	9 1 83	11 9 83
26	1	2569	9 1 83	20 5 83
27	1	2592	9 2 83	11 9 83
28	1	3202	9 1 83	11 9 83
29	1	4312	9 1 83	9 12 83
30	1	4902	10 6 83	1 2 84
31	1	4922	9 1 83	12 2 83
32	1	4502	9 1 83	10 5 83
33	1	4714	9 2 83	11 16 83
34	1	4820	23 23 63	10 1C 83
35	1	5002	9 1 83	10 5 83
36	1	5138	11 10 83	12 2 83
37	1	5156	9 2 83	9 15 83
38	1	5198	12 27 83	1 13 84
39	1	5811	9 1 83	10 11 83
40	1	6302	9 1 83	11 9 83
41	1	6310	9 1 83	2 22 84
42	1	6312	9 1 83	12 63
43	1	7112	9 1 83	11 15 83
44	1	7206	9 1 83	9 2 83
45	1	8007	9 1 83	1 17 84

PROJECT NAME : BAINBRIDGE   20 KM(S) USING UPGRADING ONLY   INTENSITY RANGE   80 - 120

PROJECT START DATE : 9 1 1983

RESOURCE USE (AVE. MAN-HOURS PER DAY) BY SHOP

SHOP   2

| PERIOD ENDED | \multicolumn{10}{c|}{C O N F I D E N C E   L E V E L} | MEAN | STD DEV |
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
112183	0	0	0	0	0	0	0	0	0	0	0.0	0.0
121983	0	0	0	0	0	0	0	0	0	0	0.0	0.0
11684	0	0	0	0	0	0	0	0	0	0	0.0	0.0
21484	50	52	56	56	59	63	64	66	68	70	59.3	8.6
31484	49	52	52	56	63	66	69	70	75	76	62.6	9.4
41184	59	63	64	69	70	74	76	79	80	93	74.3	9.7
51184	70	70	71	73	76	80	82	86	93	93	78.4	7.8
61184	66	70	71	71	75	80	82	85	90	93	78.8	9.3
71184	45	56	61	70	71	78	61	85	90	91	72.6	13.1
80984	50	56	61	63	66	73	74	75	80	86	67.4	10.4
90784	36	40	45	46	49	52	56	62	65	78	51.6	11.2
101084	0	34	49	45	42	55	63	65	68	69	50.2	20.3
110684	47	49	49	59	62	63	65	67	68	69	58.8	8.3
120584	47	49	49	59	63	63	65	67	68	69	59.1	8.3
10385	47	49	49	59	63	63	65	67	68	69	59.1	8.3
13185	47	49	49	59	63	63	65	67	68	69	59.1	8.3
30485	47	49	49	59	63	63	63	65	68	69	54.1	8.8
32985	45	47	47	45	51	59	10	21	47	65	55.5	8.8
42985	0	0	0	1	7	0	0	0	0	1	14.6	20.1
100985	0	0	0	0	0	0	0	0	0	0	0.1	0.3

PROJECT START DATE : 9   1 1983

TOTAL MAN-HOURS BY SHOP

SHOPS					CONFIDENCE LEVEL						MEAN	STD DEV
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
2	17670	18898	19065	19405	20349	20539	20904	21291	22151	23369	20237.3	1060.5
3	1327	1337	1390	1412	1437	1460	1514	1535	1556	1653	1451.0	95.9
5	0	0	0	0	0	0	0	0	0	0	0.0	0.0
6	11986	12403	12702	12936	13161	13431	13564	13686	13705	13840	13081.0	602.2
7	128	134	141	151	154	157	161	161	162	172	150.5	13.6
9	1996	2034	2083	2119	2147	2194	2209	2235	2296	2311	2153.5	101.1
10	321	336	354	355	358	364	370	390	400	420	364.0	27.3
11	93553	94235	94407	95388	95693	96037	96165	96210	96274	96047	95362.1	1007.9
12	0	0	0	0	0	0	0	0	0	0	0.0	0.0
13	1161	1249	1279	1291	1365	1311	1320	1375	1395	1475	1310.9	80.2
14	32	34	37	38	39	40	41	43	45	47	39.3	4.9
16	0	0	0	0	0	0	0	0	0	0	0.0	0.0
17	68052	68189	68600	68872	69402	69619	69721	69869	70324	70644	69241.9	812.1
19	19280	20911	21007	21124	21921	22070	22073	24283	24905	26075	22153.1	1962.9
20	417	417	427	430	470	475	426	468	497	513	459.2	33.8
22	1206	1260	1286	1314	1414	1439	1518	1565	1640	1667	1418.5	153.1
23	1922	1943	1947	1962	1969	1973	1984	1988	2002	2033	1970.0	30.5
24	3747	4216	4369	4550	4644	4721	4630	4983	5154	5229	4615.7	429.1
26	97818	98126	98715	98852	99165	99511	99545	99954	100118	101239	99426.7	1076.0
30	11422	12242	12477	12806	12879	13072	13711	13769	14024	14370	12996.0	694.4
31	108505	108586	109083	109693	110211	110354	110657	111368	111947	113408	110205.0	1399.8
32	8387	9200	9901	10416	10494	10671	11343	11370	11841	12044	10467.7	1102.9
33	2641	2605	2682	2800	2811	2831	2939	2948	2973	3041	2818.4	130.6
34	19426	20298	20663	20934	21182	21554	22369	22559	23064	24594	21584.4	1532.9
35	10503	10591	11042	11173	11566	11785	11929	12068	12515	13021	11563.2	767.0
36	19	19	26	23	23	24	25	25	26	27	22.5	2.8
37	19	20	22	22	23	24	25	26	27	28	23.3	2.9
38	189368	191120	191247	192397	192842	193030	193778	194261	194479	198207	192640.8	2490.0
39	15289	16124	16655	16797	17205	18090	18585	18719	20491	21328	17731.7	1786.1
40	0	0	0	0	0	0	0	0	0	0	0.0	0.0
41	47150	47857	48814	49279	49356	49917	50794	50865	91852	52605	49695.6	1621.9
42	128	129	140	146	156	166	172	179	188	191	157.4	21.8
47	7	8	8	8	7	9	7	10	10	11	8.4	1.2
50	7	6	6	7	7	9	7	7	9	9	6.8	1.4
51	152164	153039	154235	154590	155247	155735	156275	157096	157942	159781	155255.2	2235.9
56	298709	300974	301526	302234	304515	309185	310457	312413	313488	315595	306325.4	5076.9
57	90675	96656	98763	99323	100371	101796	102670	104705	105954	108524	100470.0	9015.3
62	1058	1080	1107	1124	1149	1167	1212	1250	1255	1343	1148.7	51.6
64	30205	30485	30703	30992	31261	32075	32395	32516	33069	34627	31727.2	1457.0
67	92662	93286	93442	93857	94858	95305	95873	96066	96427	101300	94923.5	2018.8
70	227	233	248	253	262	276	278	291	302	306	265.0	27.5
71	96072	97594	98746	99464	100510	102042	102479	102512	102858	105966	100574.0	2910.9
72	122863	123799	125873	129376	130534	132261	137737	139774	140960	147431	132219.2	7569.6
81	2490	2499	2516	2519	2577	2590	2609	2637	2655	2721	2572.1	73.5
94	745	758	704	771	779	781	786	792	808	810	776.1	49.2
99	35407	36915	38113	38940	39255	39656	40252	40862	41619	42352	39142.4	2601.4

PROJECT START DATE : 9 1 1983

DATES OF MILESTONES

MILESTONE	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	MEAN	STD DEV
503	831005	831005	831005	831005	831005	831005	831005	831005			831005.0	0.0
342	860512	860512	860512	860512	860512	860512	860512	860512			860511.2	557.9
250	841227	841228	850101	850102	850103	850104	850107	850108	850121		847885.6	3605.7

SIMULATED REALIZATION
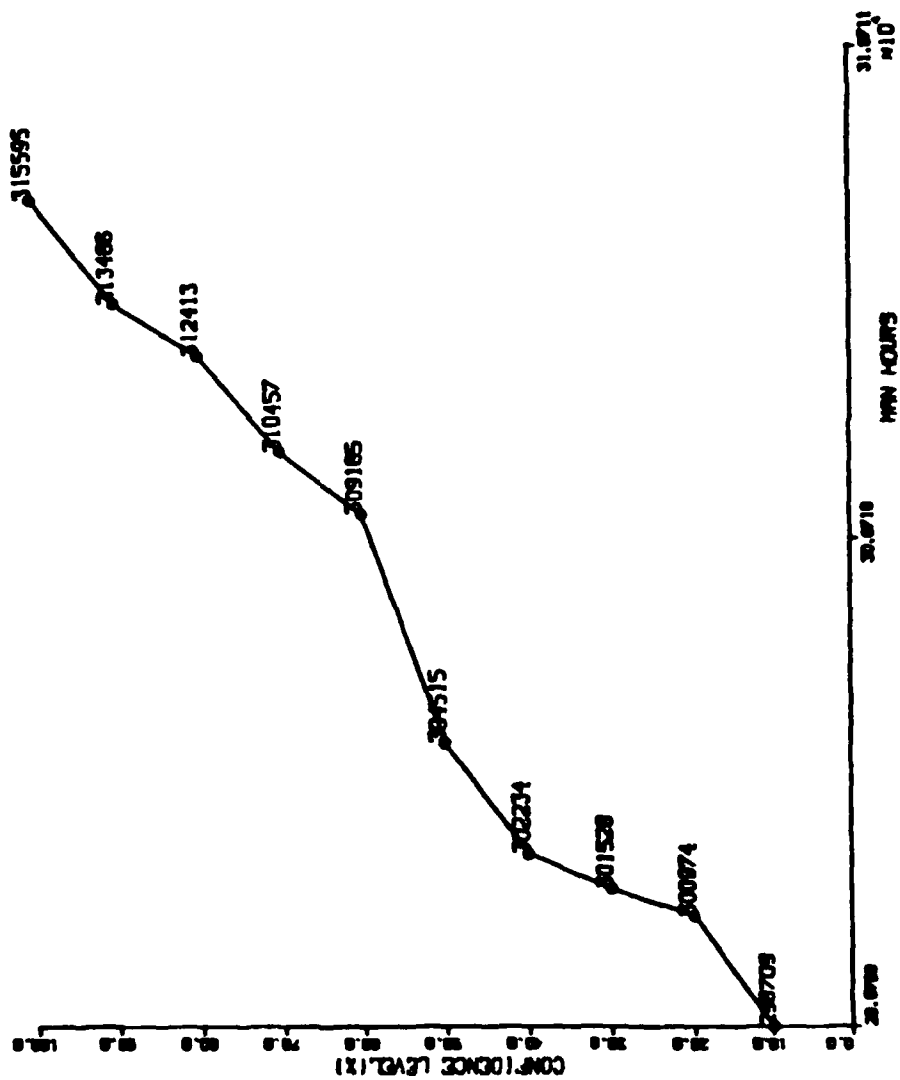OF MILESTONE = 850
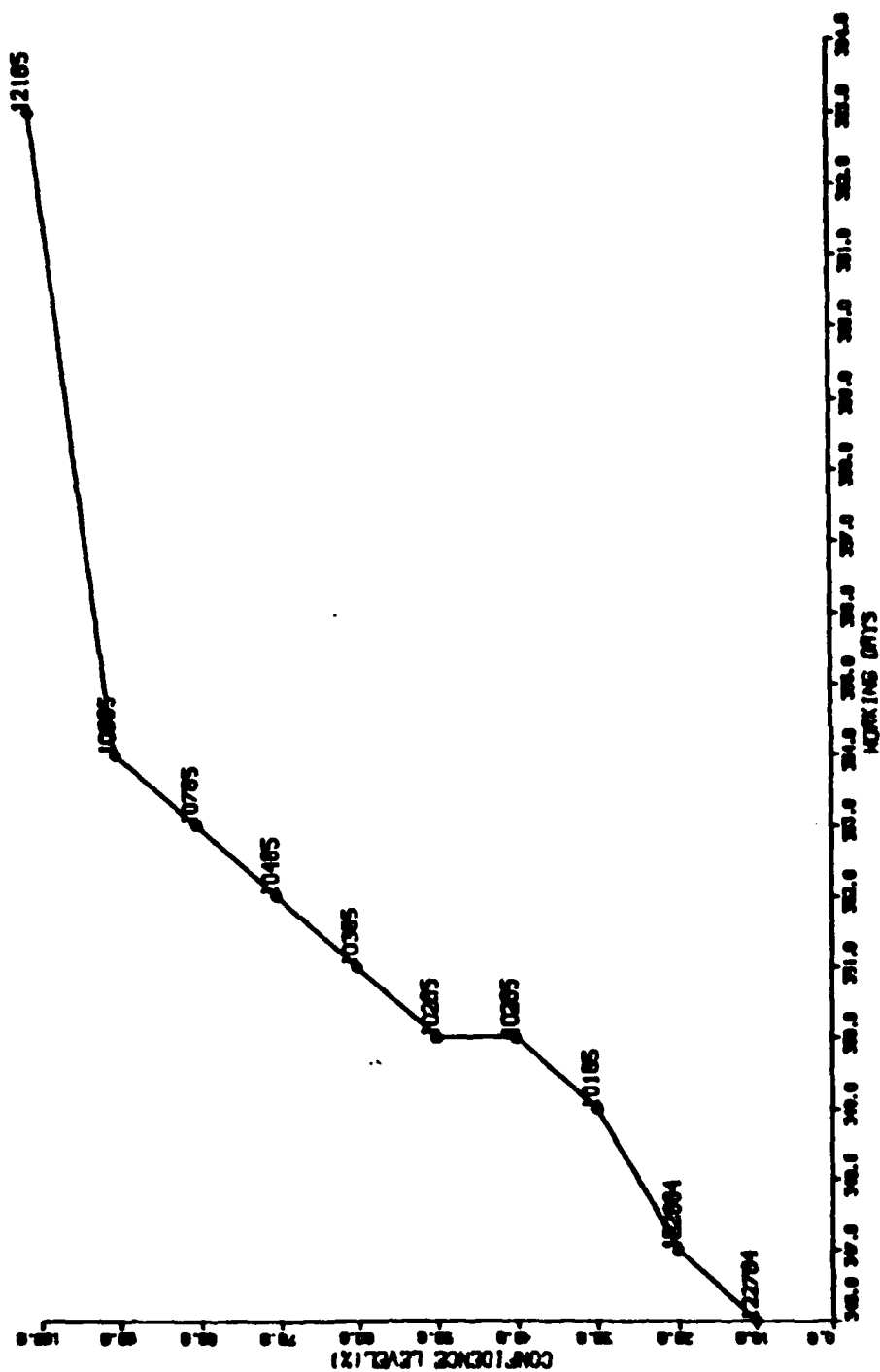
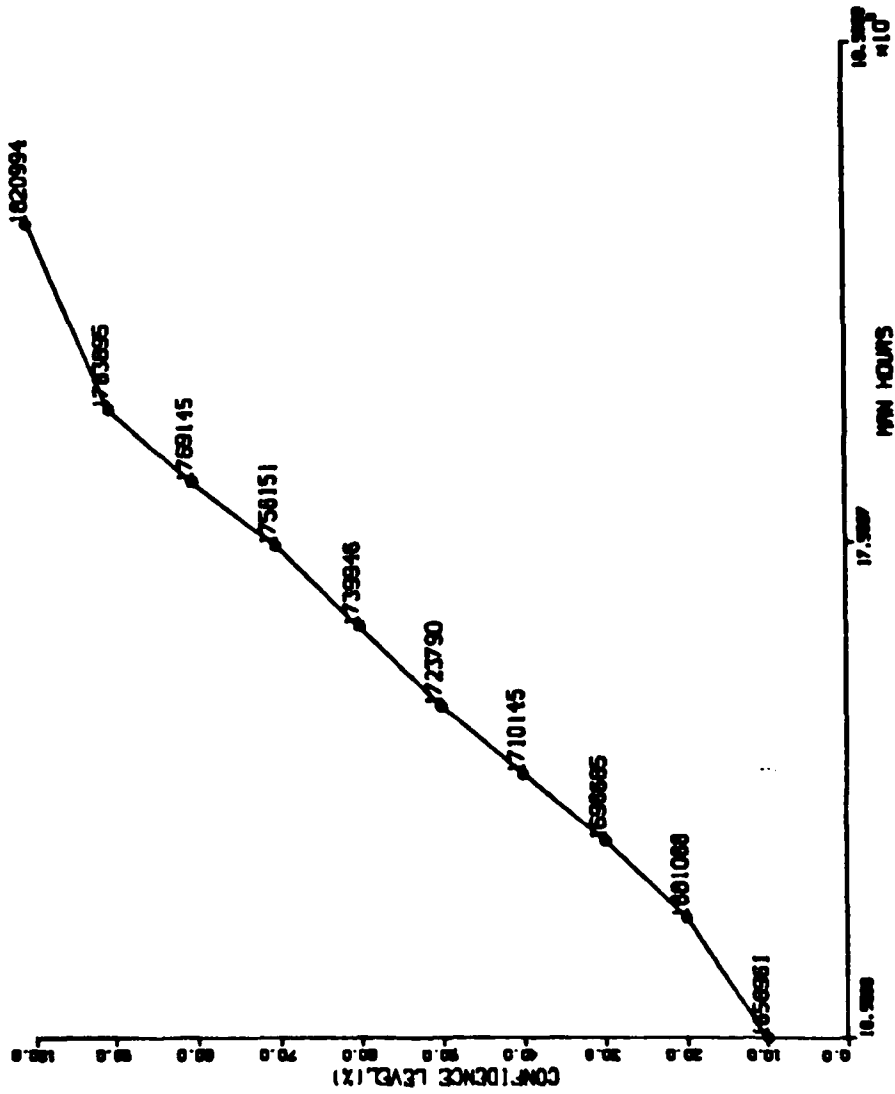SIMULATED LOAD PROFILE

CONFIDENCE LEVEL: 100
FOR RESOURCE: 51
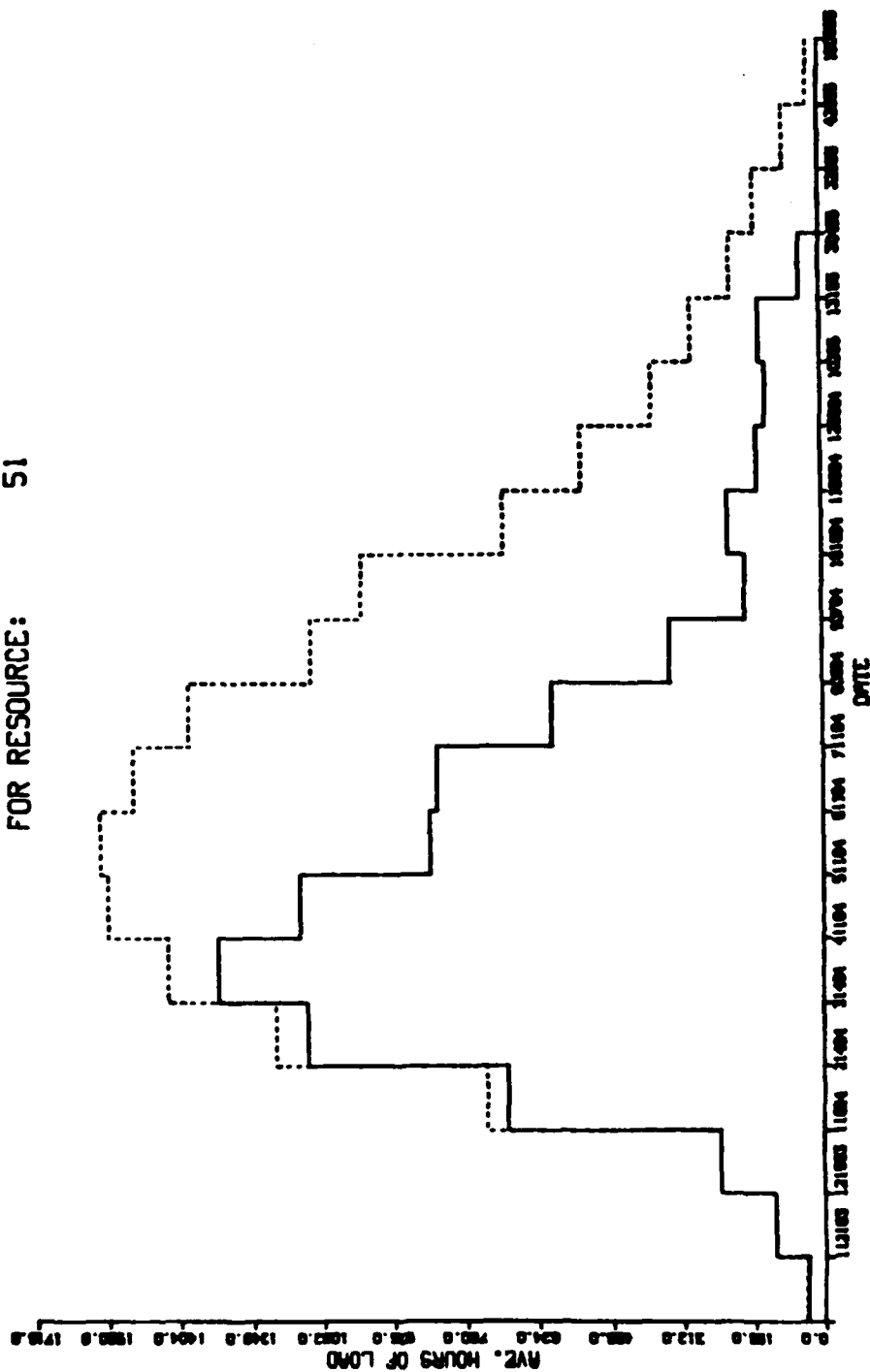
SIMULATED TOTAL REQUIREMENT
FOR RESOURCE = 56

SIMULATED TOTAL REQUIREMENT
FOR RESOURCE # ALL

END
DTIC
7 - 86